The Dark Energy Survey (DES): Science Goals and Current Status

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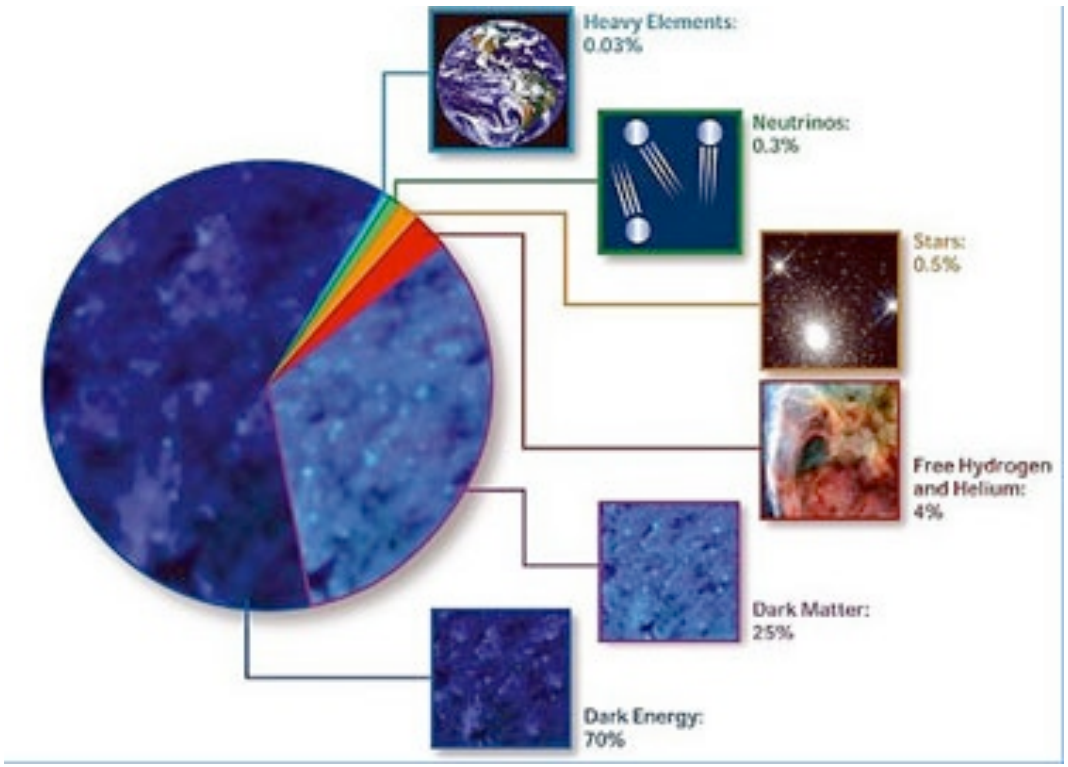
Argonne Postdoctoral Research Symposium
September 8, 2010

Dark Energy, Dark Matter, and Us



The contents of the universe, according to observations made within the last decade, have led to the adoption of the Standard Cosmological Model--ΛCDM: Cold Dark Matter with a constant expansion parameter (Λ) known as the "Cosmological Constant" or, less charitably, as "Einstein's Biggest Blunder."

Dark Energy Survey: Science

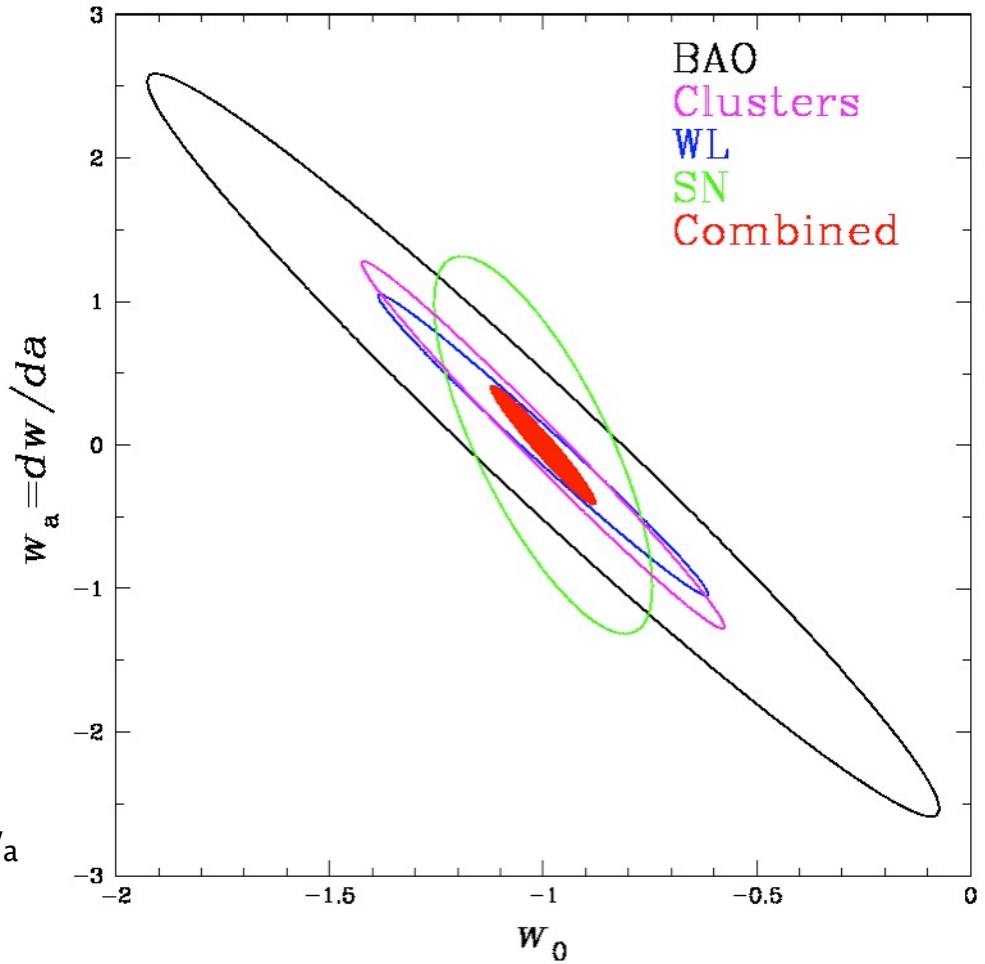
The properties of Dark Energy can be expressed in terms of the Equation of State at different redshifts:

$w(z) = p/\rho$

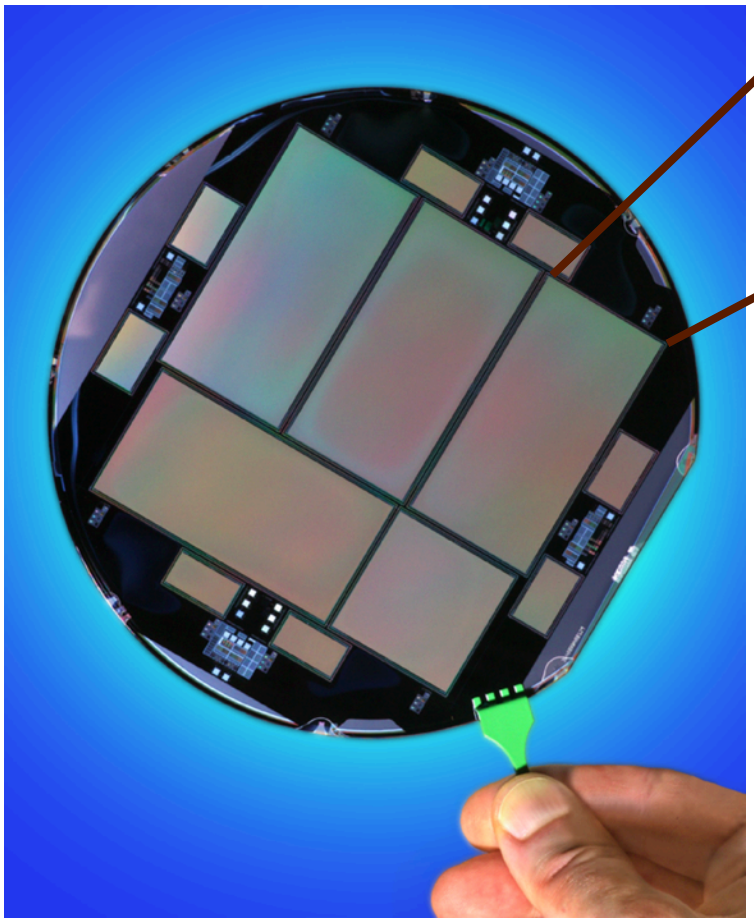
We parameterize w(z) as follows:

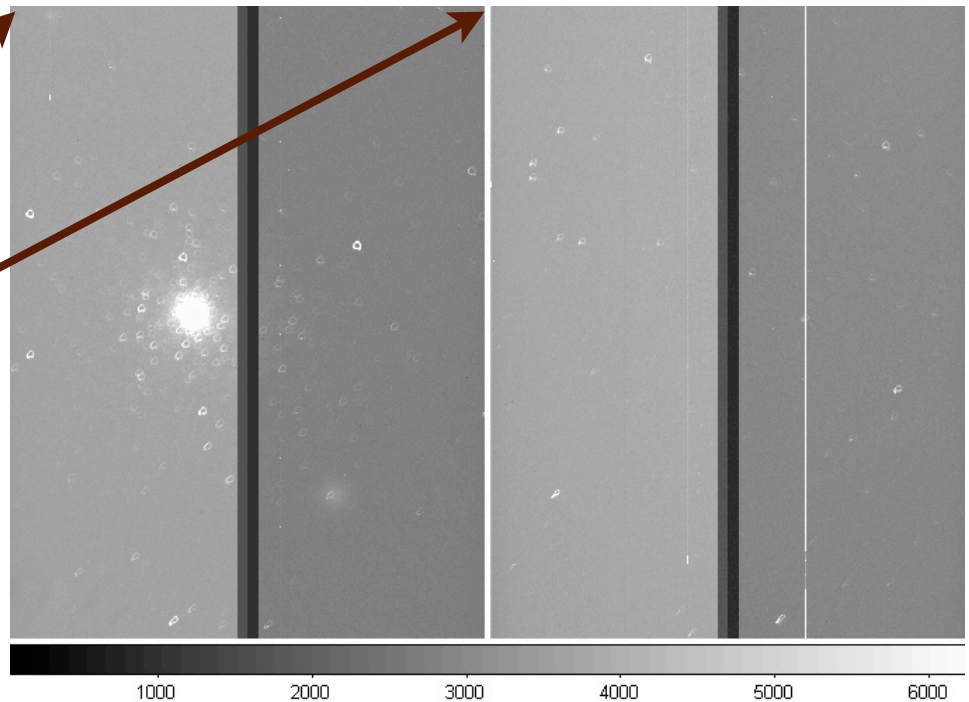
$w(z) = w_0 + w_a(1-a)$, where **$a=(1+z)^{-1}$**

The Dark Energy Survey (**DES**) will repeatedly observe 5000 deg^2 of the southern sky, with the ultimate goal of measuring the expansion history of the Universe through the dependence on redshift of the luminosity distance, angular diameter distance, and volume element, along with the growth rate of structure. DES will significantly improve the precision of measurements of both w_a and w_0 (see Figure at right).



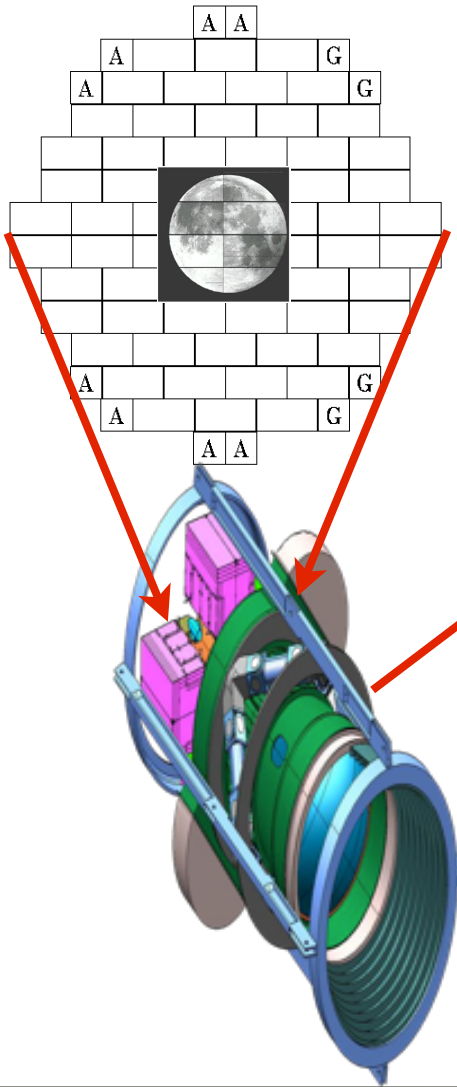
Dark Energy Survey: Instrumentation

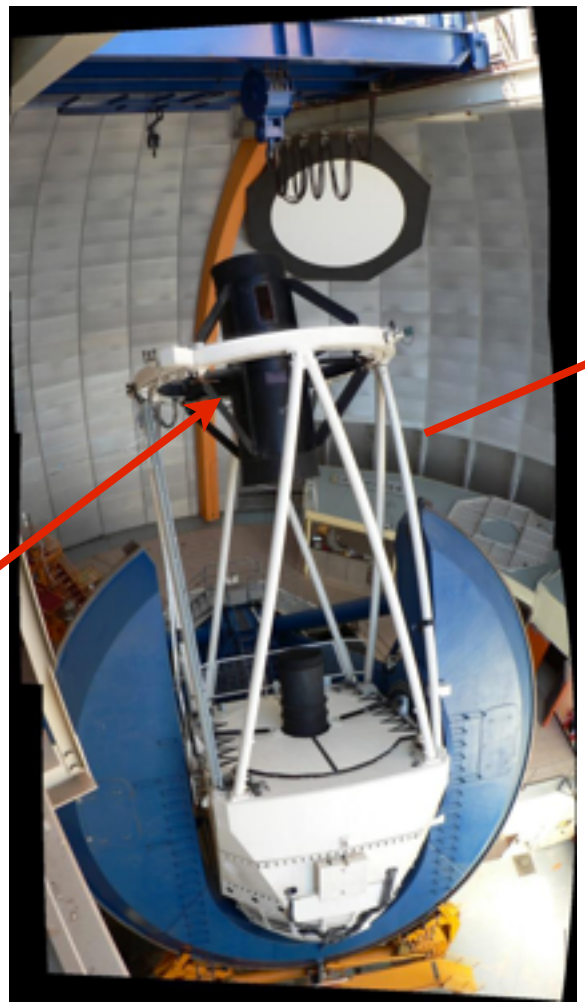


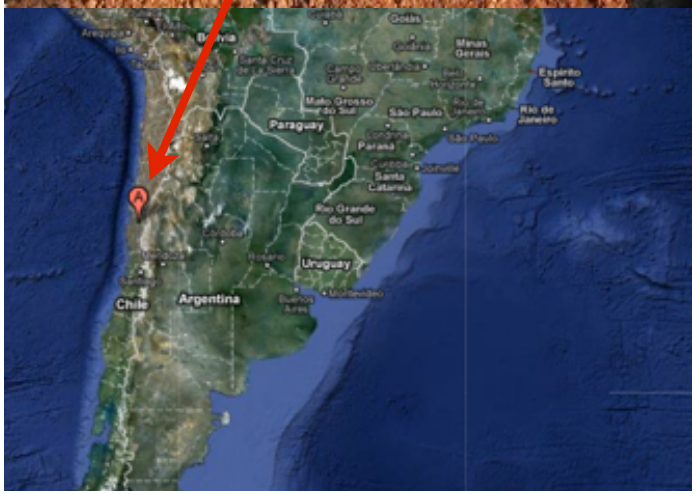


DECam consists of 62 2k x 4k extremely red-sensitive (QE > 50% at 1000nm) CCDs capable of capturing 3 square degrees of the Southern sky in a single image.

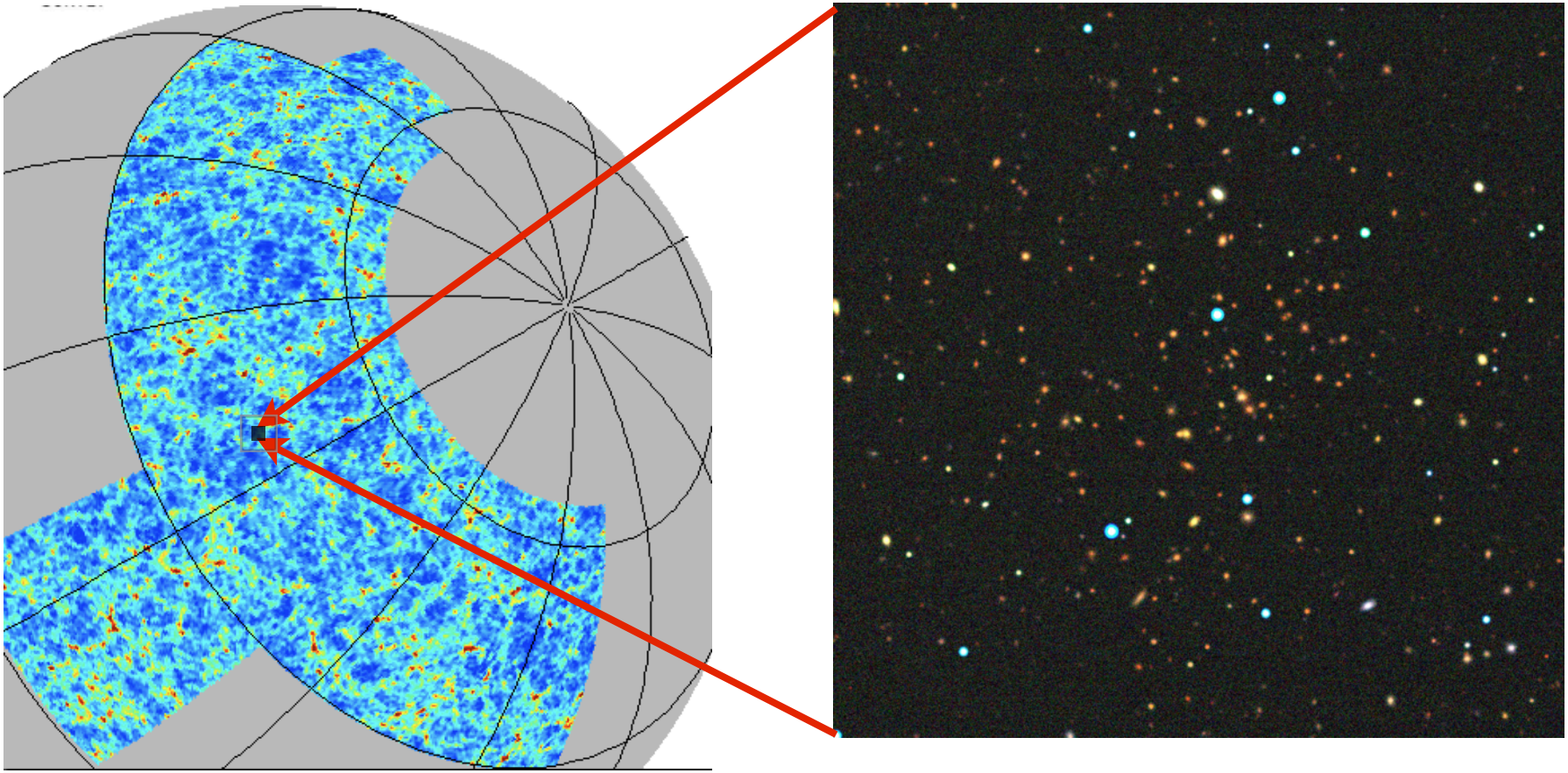
Dark Energy Survey: Telescope and Observatory





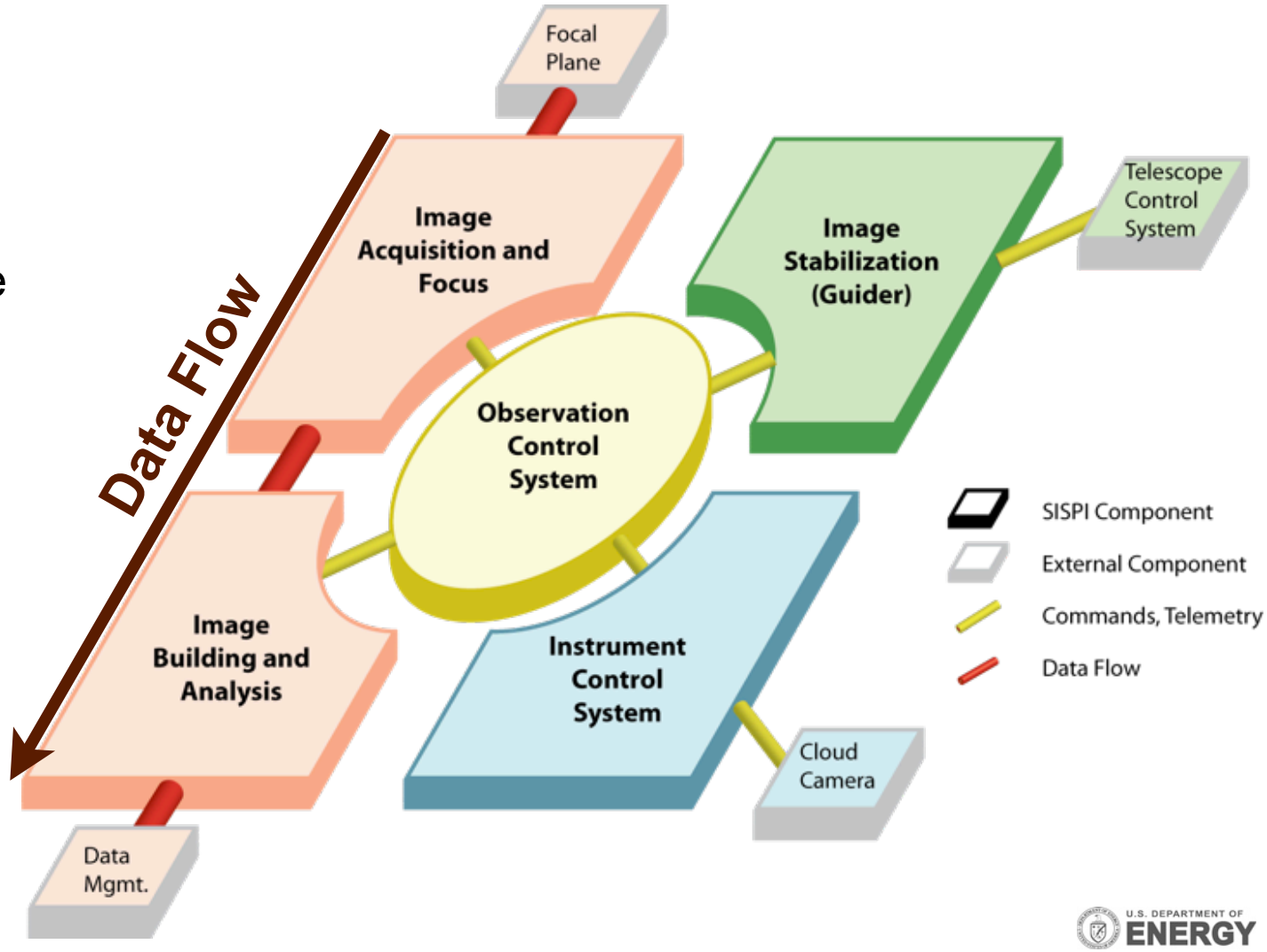


Dark Energy Survey: Footprint and Single Image



Dark Energy Survey: Software Infrastructure

The "Survey Image System Process Integration" is the central nervous system of the DES data-taking enterprise, and controls everything from telescope position to data transport off the mountain.



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Dark Energy Survey: Analysis Techniques and Timeline

Four separate analysis techniques with independent systematics will be applied to the DES observations:

- Baryon Acoustic Oscillations
- Galaxy Cluster Mass Distributions
- Weak Gravitational Lensing of Galaxy Clusters, and
- Supernova Ia Light-curve evolution

(several auxiliary science programs are being planned as well)

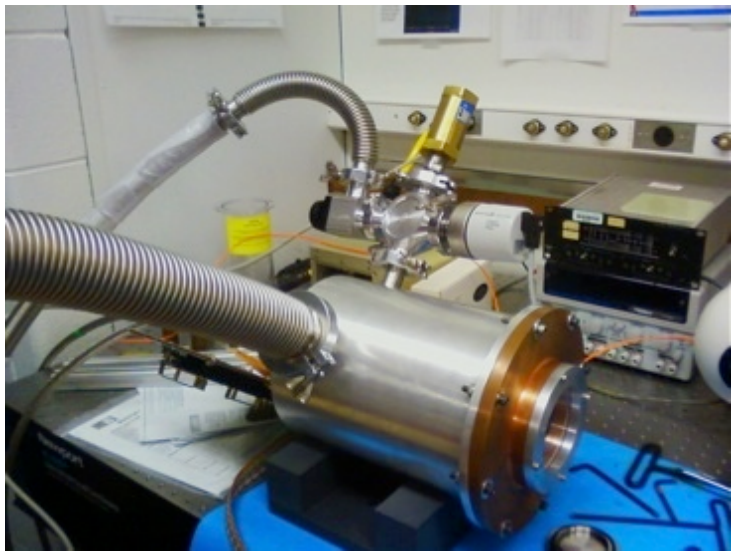
The Dark Energy Camera is currently being constructed and tested at Fermi National Accelerator Laboratory. Installation of the completed instrument will begin in 2011, with "First Light" expected in early 2012. The Survey will occur during 525 nights over five years, at which point the four complementary analyses will provide unprecedented constraints on the Equation of State of Dark Energy.

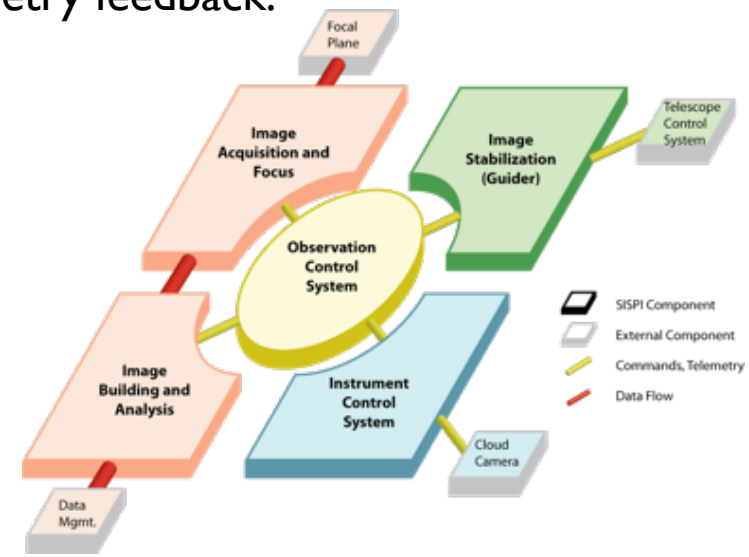
In addition to the design and construction of DECam, significant effort is going into simulations of expected DES data, theoretical determinations of the science output, and pre-Survey calibrations...

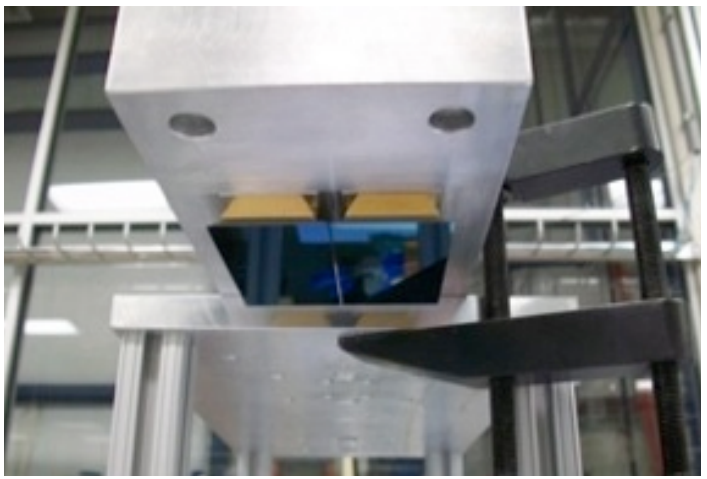
U.S. DEPARTMENT OF ENERGY

PreCam: the DES Precursor Camera

PreCam consists of two 2k x 4k CCDs identical to those that will be used in the Dark Energy Survey, along with a pressure control system, cryogenics, and other hardware functionally similar to DES. PreCam also provides a test of DES-style filters, readout electronics, and software infrastructure for instrument control and telemetry feedback.







PreCam is scheduled for 100 nights, including installation and commissioning, on the Curtis-Schmidt (University of Michigan) Telescope at Cerro Tololo starting in **August 2010**.

PreCam's "Rib and Keel" observation strategy is expected save DES 10% of its survey time by providing calibration data for hundreds of stars per square degree in a sparse grid across the DES footprint.

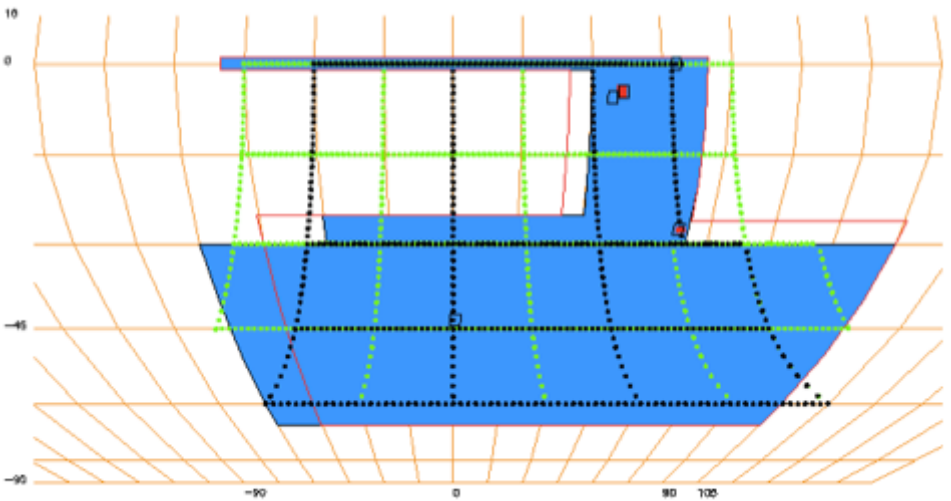
Calibration data include extinction standards and nightly photometric solutions which will contribute to improving DES global relative calibrations from its 2% requirement to its 1% goal.

It will also contribute to color transformations based on numerous observations of SDSS Stripe 82, and it will provide Y-band observations of standard stars, which are currently very sparse in the Southern Hemisphere.

Finally, it will provide a bright star catalog for subsequent DES Image Quality tests as well as science data for bright objects in the DES footprint such as Milky Way red giants or local supernovae.

Table 1: Exposure Calculations for Point Sources in the Baseline PreCam Survey

Band	PreCam Exposure Time [seconds]	PreCam saturation limit	DES saturation limit (100s exposure)	PreCam mag limit (S/N=50)	PreCam detection limit (S/N=5)	# Stars per sq deg, DES sat to PreCam S/N=50
(1)	(2)	(3)	(4)	(5)	(6)	(7)
g	36	12.8	16.3	17.8	20.9	186
r	51	13.2	16.3	17.8	20.7	265
i	65	13.4	16.2	17.7	20.5	344
z	162	14.1	16.0	17.5	20.1	317
y	73	11.6	14.3	15.8	18.5	150

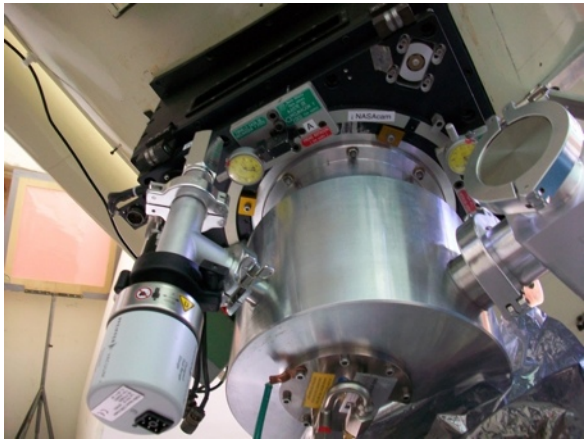


= DES footprint = PreCam "Rib and Keel"

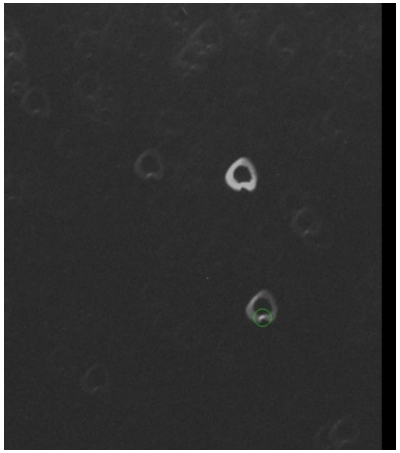
PreCam Status (as of 2010-09-07)

Shipped to Cerro Tololo, Chile

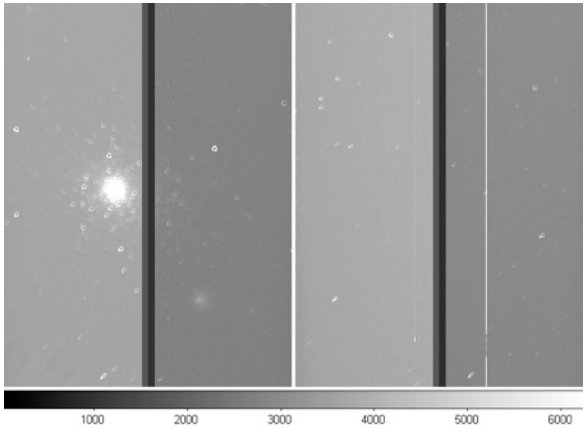
Installed on the Curtis-Schmidt



Commissioning Completed



Optical Alignment Underway



First Light Image of 47 Tuc

Conclusions and Outlook

The Dark Energy Survey, utilizing the Dark Energy Camera on the Blanco Telescope at Cerro Tololo Inter-American Observatory, is designed to constrain the time-independent and time-dependent terms of the Dark Energy Equation of State. It is on schedule to achieve "First Light" in early 2012.

It will observe 5000 square degrees of the sky multiple times utilizing five different filters over 525 nights of a five-year survey. It will observe several hundred million faint galaxies, galaxy clusters, supernovae, and weak gravitational lenses in order to obtain its key science goals. Auxiliary science goals involve Galactic Archaeology/ Milky Way Structure and Evolution, Strong Gravitational Lensing, Galaxy Evolution, Transient Science, and many other topics.

PreCam, designed and constructed at Argonne, is a central component of the DES Calibration efforts. PreCam is currently installed on the Curtis-Schmidt telescope at CTIO and, once optical alignment is completed, will be taking data nightly during the months of September, November, December, and January.